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FINAL REPORT

TEST AND SIMULATION PROGRAM

PROJECT 9015.12

April 1963

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INTRODUCTION

Section I

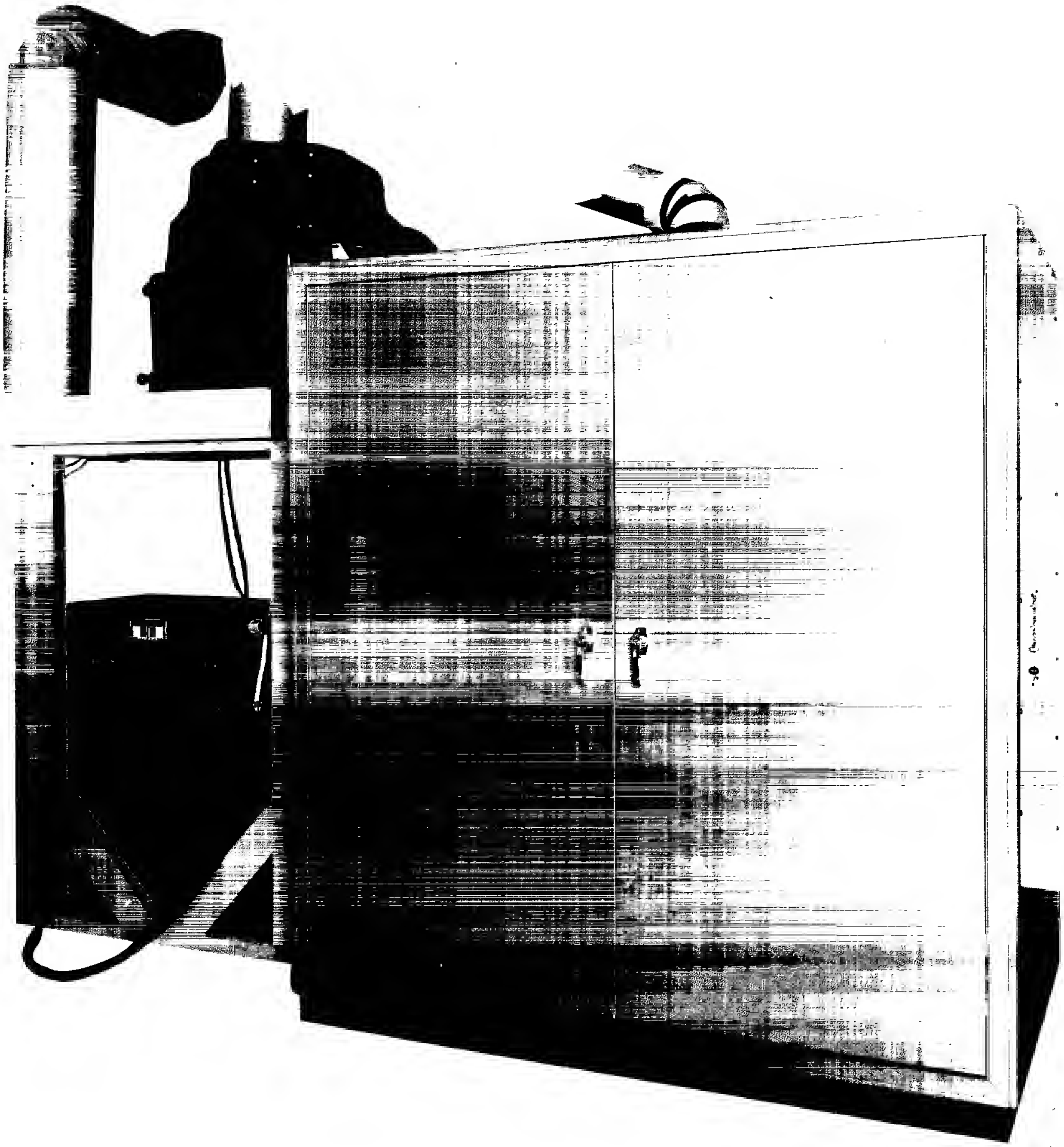
INTRODUCTION

The Itek Corporation has designed and built a processor as part of a coherent high resolution data system. This unit, shown in Figs. 1, 2 and 3, has remained at Itek for further development and testing. For this purpose, a Test and Simulation Program was carried out during the latter part of 1961 and 1962. This report describes the tests made and the results obtained on that task.

A. PURPOSE AND GOALS

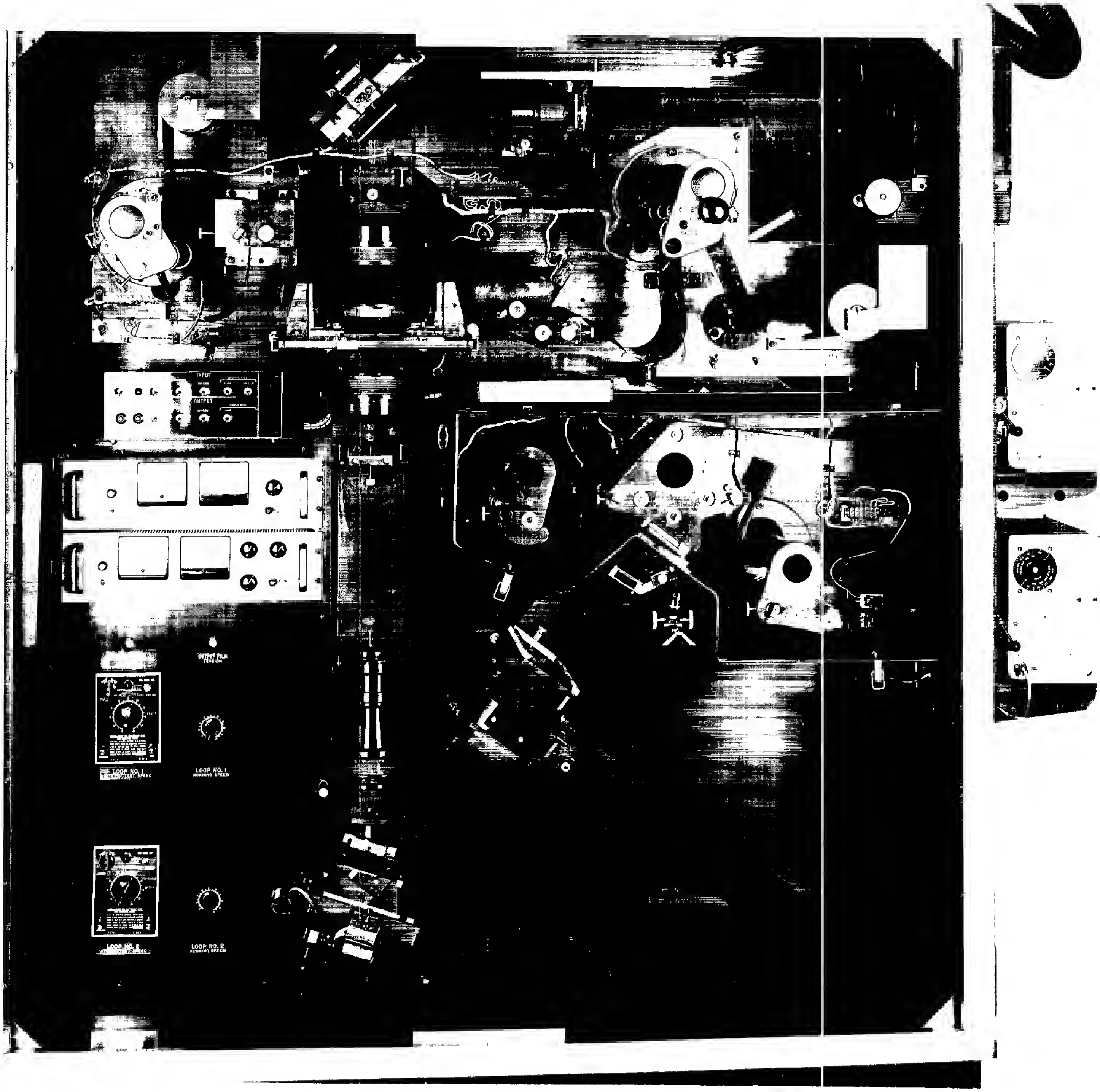
The Test and Simulation Program was initiated to optimize and measure the performance of the processor. The concepts embodied in the overall radar system and in the processor are relatively new, and it was anticipated that there would be some development work required before the anticipated performance would be achieved. The initial contract only covered the construction of the processor; the test and simulation program is the continuation of the program to carry out the development work.

The goals outlined in the proposal were to make suitable simulated targets and perform specific tests to optimize the performance of the processor and obtain quantitative data on its capabilities. The simulation input data to be generated were "square wave" hand ruled patterns which would be reproduced alone and in small groups on



Exterior view of processor (rear)

Figure 1.



Interior view of processor (front)

Figure 2.

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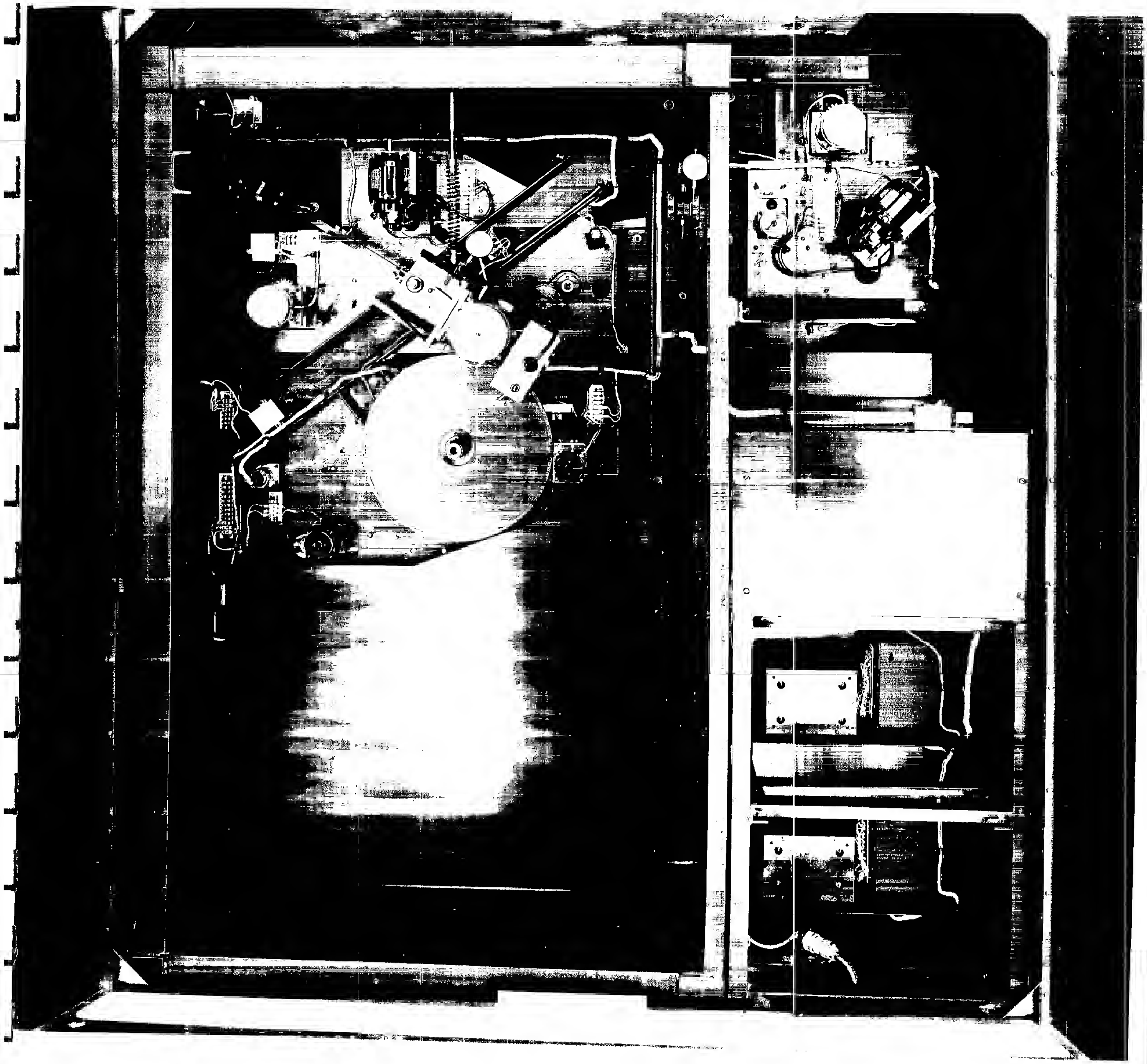
SPECIAL HANDLING



Interior view of processor (rear)

Figure 3

photographic film. The tests to be performed were listed as:

- Resolution in range
- Point size in azimuth
- Azimuth signal separation
- Focal length compensation
- Pattern tilt
- Effects of pattern focal length variation
- Signal integration (noise effects)
- Film drive

The results obtained were major improvements in the operation and performance of the processor and measurements of the performance of the processor. The difficulty of interpreting the test data has lead to a de-emphasis of the collection and analysis of a large amount of data; rather, the effort has been concentrated on obtaining better and more reliable measurements. The performance data obtained to date is summarized in Table IV in Section IV.

B. NATURE OF THE TESTS

The Test and Simulation Program has had the nature of a study and development effort aimed toward the improvement and understanding of the processor as well as the collection and interpretation of data. The difficulties of optimizing the performance of the processor were foreseen (although not accurately estimated) which is why this program was proposed. Many of the difficulties arise from the following considerations:

1. The processor utilizes a novel and complex optical system which does not follow usual optical practice in detail. The usual optical engineering procedures often are inadequate and recourse must be made to observing the resultant image from simulated input data to proceed with alignment, testing, and learning the details of the reconstruction process.
2. The processor is an integral part of a complex radar system which is not completely understood and which uses novel components and techniques. One of the largest single problems (lack of adequate quality cylinder lenses from February to November 1962) was attributed to the interaction of the processor with the overall system.
3. The interpretation of the images obtained is very complex. Adjustments in focus or other parameters often produce recognizable changes in the image, but it is difficult to decide which setting is better. When final measurements are made, it is often difficult to access them in terms of overall system performance.
4. The processor was designed to have considerable flexibility over narrow ranges of adjustment, but it is not amenable to any major changes. Many details of the

design were optimized for operational running after adjustment, this produced an instrument which is not well suited to continued testing*.

5. The requirements on the film drive are very severe, and they led to a drive incorporating novel techniques. The requirements are such that it is difficult to test the drive independent of the optical system, and impossible to test it to full accuracy. This has caused many delays in the work on the optical system.

C. OTHER PROGRAMS ON THE PROCESSOR

Two other interrelated programs have been run concurrently with the same personnel and equipment. There are processor modifications, incorporating major improvements into the unit, and F101 flight test support. Most of the requirements for modifications arose during testing, and the modifications contributed to obtaining better data. The flight test has been our only other source of data for the processor, and much of the work with the flight films has contributed directly to the general goals of the test and simulation program, viz: to improve the operation of the processor. However, the flight films have not been useful for quantitative testing of the processor as a subsystem, and they are not described in this report.

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*For a partial discussion of the problem and some steps to improve the situation, see the December 1962 Progress Report.

Section II

CHRONOLOGICAL DESCRIPTION OF THE EFFORT

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The overall project (Itek No. 9015) started in August of 1960. The unit was designed, fabricated, and assembled in approximately 13 months. In August of 1961, a proposal* for a Test and Simulation Program was submitted. This proposal suggested two methods of generating simulated data to put into the processor, and a list of tests to be performed. This proposal was modified in October (the computer programmed target simulator was deleted) and initial authorization was received. The first step was to make a small target and reduce it to a 24 inch focal length in November. These targets were put into the processor and images obtained in mid November. This test was repeated as part of the acceptance test late in November. A new simulated target was ruled during December and photographically reproduced in January. An attempt was made during December to rescale some data film borrowed from another coherent radar system and use it in our processor, but this was unsuccessful.

The new 24 inch focal length targets were correlated in January and the images were recorded on film. Some tests were performed to check on the expected reaction of the processor to misalignment. A check on range resolution capabilities late in the month lead to some

*See Appendix A for a listing of proposals and reports.

unexpected results which pointed up the difficulty of testing any component outside of the overall system.

The schedule on the F101 flight tests required that the processor be converted to a 150 inch focal length system during February. This hindered the test program by taking considerable time and complicating the system since the additional cylinder lens could not be adjusted, and it was a cylinder of poor quality. It was anticipated that this situation would be corrected in May with newly designed lenses and mounts, but the lenses were not received until November.

Targets with a 150 inch focal length were used in the processor to set it up for receipt of the first flight film. During this work an image spearation of .0045 inch was obtained. Some targets with a range width of .001 inch were made and correlated. Some tests were made using wrong wavelengths, partially blocked apertures, low contrast targets, and various misalignments. These gave the expected qualitative results. A number of targets were printed onto a long length of $9\frac{1}{2}$ inch wide film for dynamic tests. Static and dynamic tests gave the same line width (.005") and separation (.0045"). Further efforts to improve the resolutions lead to the conclusion that the cylinder lenses were limiting the ability to properly optimize the processor, and was severely limiting the image quality obtained in any case. Some further effort was devoted to some initial tests on noise and film

drive settings, but the poor cylinder lenses prevented obtaining good data, and further work on the test and simulation program was deferred until new cylinder lenses were installed.

A proposal to continue the program was submitted during the summer of 1962. The tests suggested were a continuation of the same basic goals (i.e. improve and measure the performance), but they are specifically oriented toward the performance in the overall radar system, whereas the original test and simulation program (the subject of this report) was primarily oriented toward the performance of the processor itself.

The new cylinder lenses were installed in November, and the testing program was continued to optimize and measure the performance of the processor. A line width of .003 inch and separation of .0027 inch was obtained, but the goals of approximately .001 inch could not be attained. Progress was slower than desired and a number of steps were taken to speed-up the laboratory work. In February, a line width of .002 inch was photographed and it was found that the simulated targets were apparently limiting the azimuth resolution. New range resolution tests were performed using a better 40 l/mm resolution target. Limiting resolution testing was abandoned as being meaningless in this system; instead the contrast of the images was used as criterion. This is a much more difficult procedure and the first tests gave only qualitative contrast data.

The testing will continue on the processor with the new patterns.

At present, work is proceeding on the manufacture of more accurate simulated patterns and the improved analysis of range resolution results. Continued effort to improve and measure the performance will be phased into the overall system studies described in the added scope proposal.

Section III

SIMULATED PATTERNS

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The processor normally uses data from a coherent side-looking radar system as an integral part of its optical system. Very little meaningful work can be done on the processor without that data or simulated data. For this reason, the first step was to generate a pattern which would simulate that data.

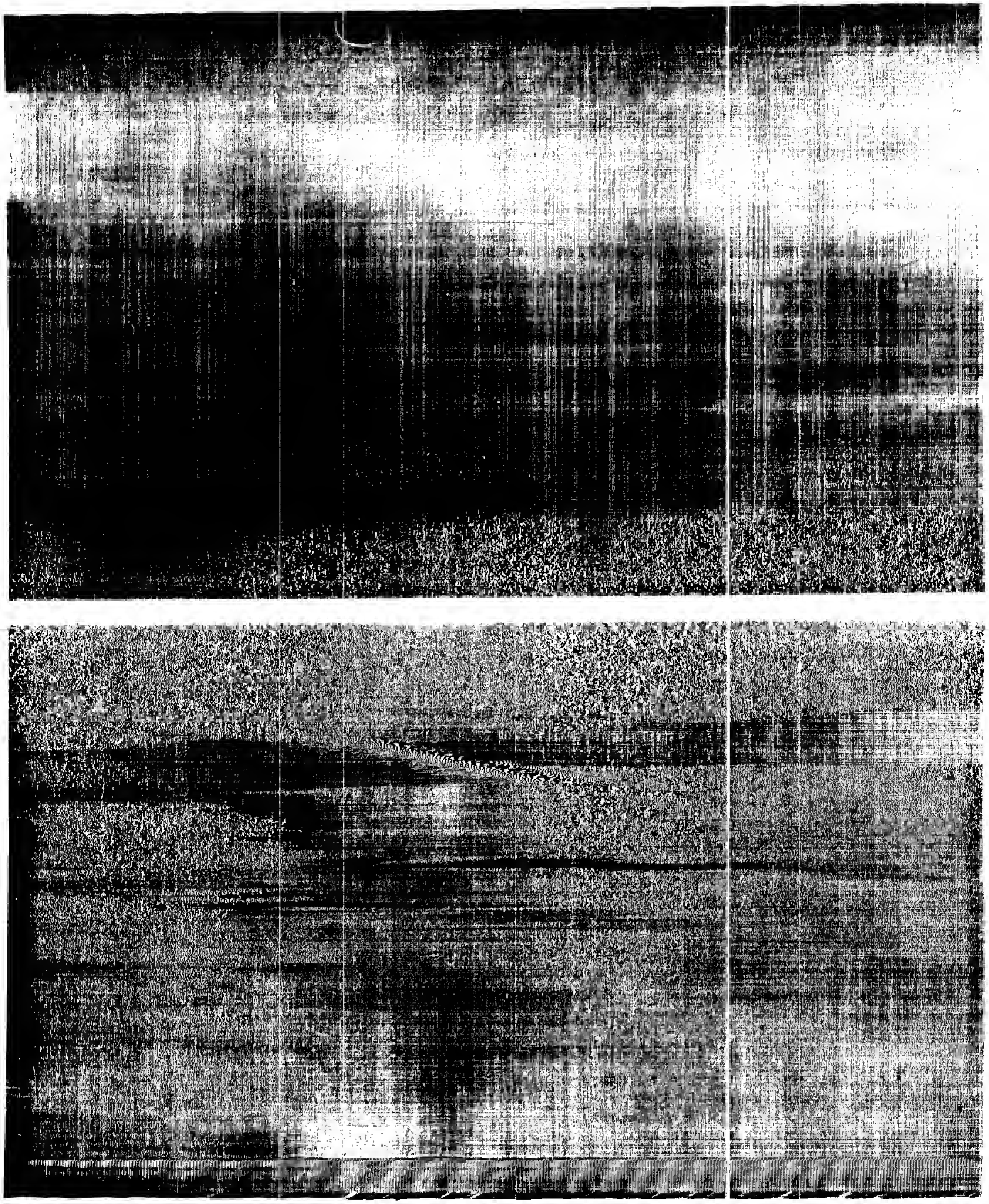
A. REQUIREMENTS

The data produced by the radar is an overlayed complex of dots on a photographic film as is shown in Fig. 4. Each point in the scene gives rise to an exposed line lying along the azimuth direction. This line varies in transmission along its length in a specific fashion as determined by the physics of the radar situation*, such that

$$\sqrt{T} = T_o + A \sin kx^2$$

where T is the film transmission, T_o is a nominal transmission, A is related to the modulation, x is distance along the film, and k is a constant for one pattern dependent on the parameters in the radar system. This variation is commonly characterized by electronic engineers as a linear FM (frequency modulation) signal, and it is described by optical engineers as a slice of a zone plate. The data film obtained by flying

*This formulation is developed in many classified documents on the subject, especially the annual University of Michigan Radar Symposium Reports.



Typical data film (Flight test Film S37)

Figure 4.

past an ordinary complex scene is a composite of many such individual patterns.

B. PATTERN TYPES AND TECHNIQUES

A number of patterns and pattern arrays can be simulated. Single patterns can be drafted or ruled on machines to generate "square wave" patterns, i.e. those having only two transmission levels. These can be photographically reproduced to obtain any scale factor or "focal length" desired by changing the effective value of k. They could also be reproduced in a limited resolution system or a system using spatial filters in the diffraction plane to produce approximate sine wave transmission. Single patterns could be generated by recording suitable interference patterns (such as Newton's Rings). The pattern could also be generated by moving film past a narrow light source which changes in intensity in a controlled fashion (the method actually used in the recorder sub system of the radar unit).

A single pattern can also be simulated in a different sense by using a cylinder lens at the position of the data film.

Multiple patterns for specific purposes can be made by multiple printing of single patterns onto a single photographic film. This technique has certain limitations, particularly the fact that the adding of densities in overlapped patterns instead of adding radar phases gives rise to distortions in the array.

Multiple patterns could also be generated by adding phases in an interferometer system, or computing complex signals to modulate a light source in the moving film technique. These techniques could also be utilized to make an array simulating a continuous tone scene.

Most of the techniques mentioned have been investigated. The single square wave target has been made and is discussed in the following section. Some patterns were obtained using interference techniques during a study phase in 1960, but the capability of the system was limited and it was not pursued at the time. Later interest in interference techniques centered about continuous tone array simulation. A number of techniques are feasible, but difficult (and therefore expensive) and have never been formally proposed or pursued on this project*, partly because it was anticipated that F101 flight test film would fulfill the need for such pattern arrays.

The technique of modulating a light source and moving film was investigated and proposed. A fast digital computer was to be used to modulate a cathode ray tube in one of the recorders built for the radar system. This technique had the disadvantage that the limitations of certain computer functions would preclude generating a continuous tone array, and the technique would inherently include the recorder and its problems in the resultant data. After further considerations, this

*A new technique holds promise of attaining useful results without a complex interferometer-like device. It is being developed on another program.

technique was dropped from the proposal. However, later testing on the recorder program has resulted in swept FM patterns being generated for some test purposes, when these have adequate quality they will be useful as simulated patterns for the processor.

Some of the recent work has raised questions which can best be investigated with a cylinder lens pattern simulation. Such a lens is now being fabricated.

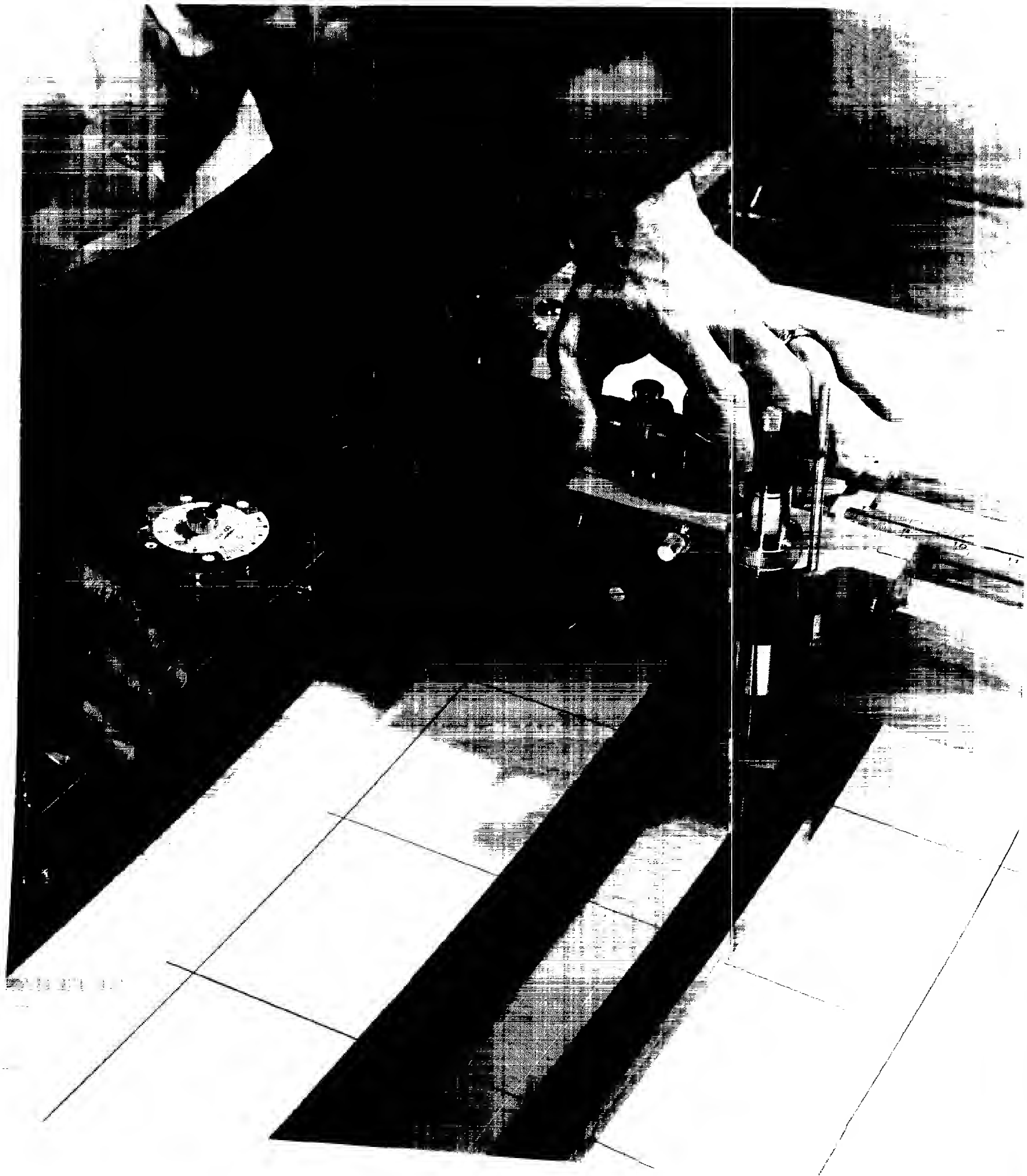
C. PATTERN MANUFACTURE

All of the pattern simulation, which has been used to test the processor, has been obtained by using a ruled pattern. This was accomplished by first making some test rulings and photographing them to establish optimum parameters for the master. One of these test rulings was used to make the 24 inch focal length patterns used for the acceptance test. The next step was to program the formulation on a Royal-MacBee computer to print out the 3000 necessary settings without error. The data results from the equation

$$x = \sqrt{\frac{n}{10}} \pm .0018$$

where + is used if n is even, - if n is odd. n is a running integer, x is the coordinatograph setting, and .0018 is the effective half width of the scribing diamond.

The ruling was done on the Haag-Streit coordinatograph, a precision measuring and ruling device shown in Fig. 5. The master was



Ruling the master on the co-ordinatograph

Figure 5.

then contact printed to give film sub-masters. These were reduced photographically in precision reticle cameras to the scale factor desired. An array of sub-masters and the resulting scaled masters are shown in Fig. 6. These scaled masters were then contact printed to give the patterns and pattern arrays used in the processor.

The first patterns used were on small pieces of film which were convenient for static tests. Later the master was mounted in a precision repeating printer known as a Misomax, and pattern arrays with accurately controlled overlaps and location were made on $9\frac{1}{2}$ inch wide film. These targets provided the bulk of the data described below.

Pattern arrays longer than 20 inches could not be held parallel to each other to the desired accuracy (one minute of arc). This was not considered serious since most tests use shorter arrays. Further experience with testing procedures, film tracking, and ever improving performance has indicated that accurate alignment is needed over the full length so the printer has recently been modified to meet these new requirements.

The phase accuracy of the targets has been a prime goal. The master was ruled to an accuracy of better than .001 inch at each point over its 20 inch length. Glass was used as a substrate to preserve this accuracy. In the sub-masters overall shrinkage only alters the scale factor and differential shrinkage should be less than .001 inch. The optical reduction process must be carefully implemented if harmful

Sub-masters and Scaled Masters

Figure 6.

distortions are to be avoided, so reduction was done on a precision camera with a low distortion lens. The reduced pattern was checked on a Mann Comparitor and found to be quite good. Some visual tests in the correlator indicated that the patterns were good. Tests performed during February 1963 indicate that the targets may no longer be perfect enough, possibly due to aging. New sub-masters are being made and carefully examined with a Foucault knife edge test.

The test films which have been made are listed in Table I and Table II. Table III describes T115 in further detail. Some photographs showing some examples of these patterns are shown in Figs. 7, 8 and 9. Overlapped arrays consisting of 2 and 5 patterns have been made with a wide range of separation. An attempt was made to overlap 30 patterns, but the sensitometric problems of dealing with many very weak exposures prevented any useful results. Some patterns were printed on grainy film to simulate noise, these are described in Section IV(G) of this report.

Table I

SINGLE TARGETS SUITABLE FOR STATIC TESTING

T-1*	Standard Air Force resolution target good to 6-6 group
T-2	24 inch** overlapped
T-3	24 inch for 3 colors
T-4*	Gurly long-lines range test target
T-5	150 inch and 200 inch singles
T-6*	Aerial Photo Boston
T-7	24 inch
T-8	24 inch three colors positioned on $9\frac{1}{2}$ inch film
T-9	200 inch .001 wide
T-10	150 inch .001 wide single
T-11	150 inch .001 wide various densities
T-12	150 inch two inch wide paste up area
T-20*	Long line 66, 88, 110 l/mm
T-21*	Long line 40 l/mm
T-22*	Long line 32 l/mm
T-23*	Long line 24 l/mm
T-24*	Long line 72, 96, 120 l/mm
. . . . .	Various 150 inch and 200 inch targets

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*Indicates test films which are not "patterns."

**The figures refer to the focal length of the pattern in green (x = 550 or 546.1) light.

SPECIAL HANDLING

Table II

TARGETS EXPOSED ON LONG LENGTHS OF $9\frac{1}{2}$ INCH WIDE FILM

T101*	scribed every 3 feet
T102*	grid and resolution for clocks positive
T103*	grid and resolution for clocks negative
T104	200 inch non squint .001 inch wide
T105	200 inch squint .001 wide overlapped
T106	200 inch non squint overlapped
T107	150 inch squint .001 inch wide various densities
T108	150 inch squint .001 inch wide overlap
T109	200 inch dot low
T110	200 inch dot medium
T111	200 inch dot double overlap high density .010 to .001
T112	200 inch dot double overlap very high density .010 to .001 sep.
T113	200 inch dot 5 overlap low density .060, .045, .030, .015, .000
T114	200 inch dot 5 overlap high density .060, .045, .030, .015, .000
T115	150 inch squinted double and 5 overlap high, medium, and low density
T116	150 inch squinted noisy double and 5 overlap high, medium, and low density
T117	200 inch non squint as T115
T118	200 inch squint as T115
T119	150 inch non squint as T115
T120	150 inch squint 71 patterns evenly spaced

T200 series. Copies of any of the T100 series.

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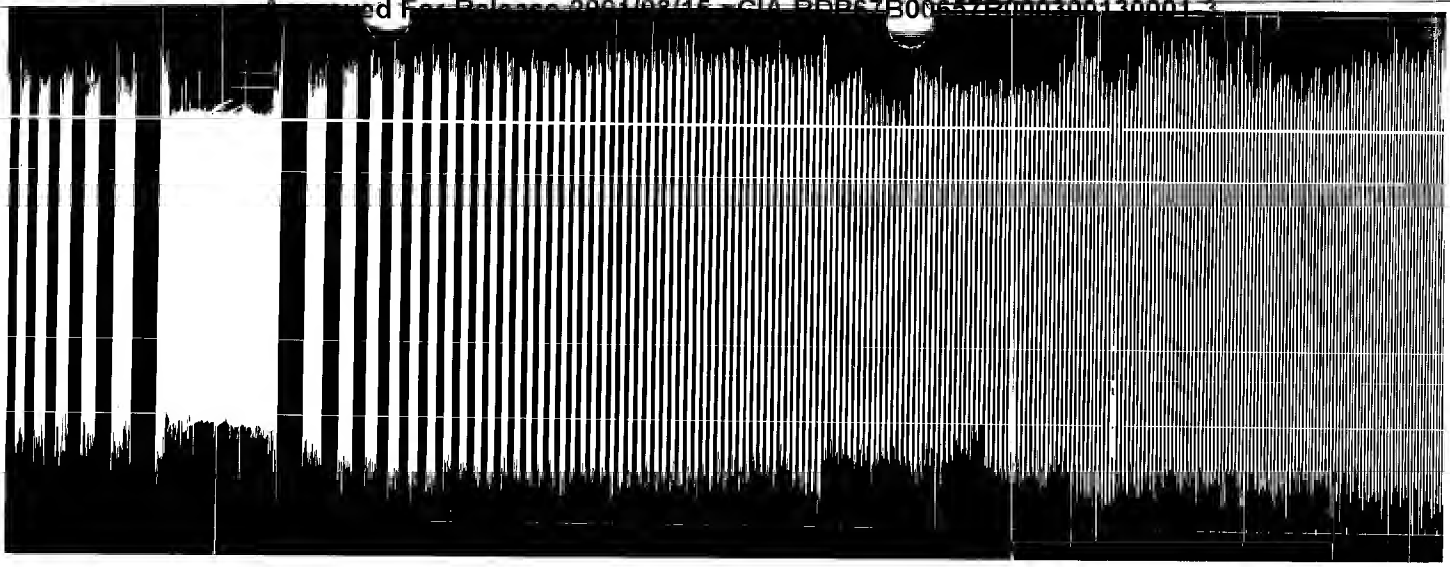
*Indicates test films which are not "patterns."

Table III

PARAMETERS OF TEST PATTERN T115

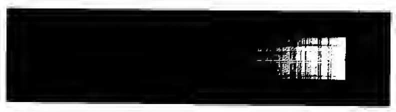
Test Film T115	Patterns Per Set	Sets Per Series	Density	Patterns (inches)
Series I	2	12	both high	.000, .040, .036, .028, .024, .016, .012, .008, .004, .000*
Series II	2	12	both medium	same as series I
Series III	2	12	both low	same as series I
Series IV	5	5	all high	.060, .045, .030, .015, .000
Series V	5	5	all low	same as series IV
Series VI	2	12	high-low	same as series I
Series VII	2	12	low-high	same as series I

*Single pattern for line width test.



a. portion of the master

b. 200 inch focal length squinted



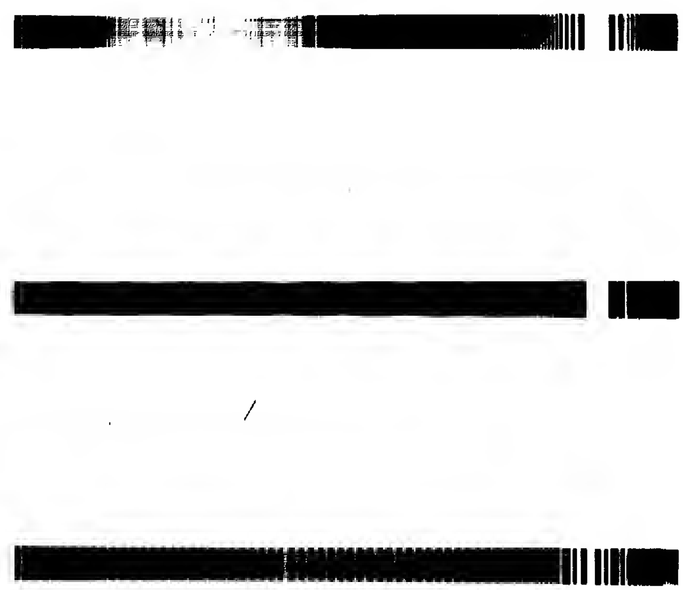
c. 150 inch focal length squinted

d. 150 inch focal length entire pattern

e. 24 inch focal length

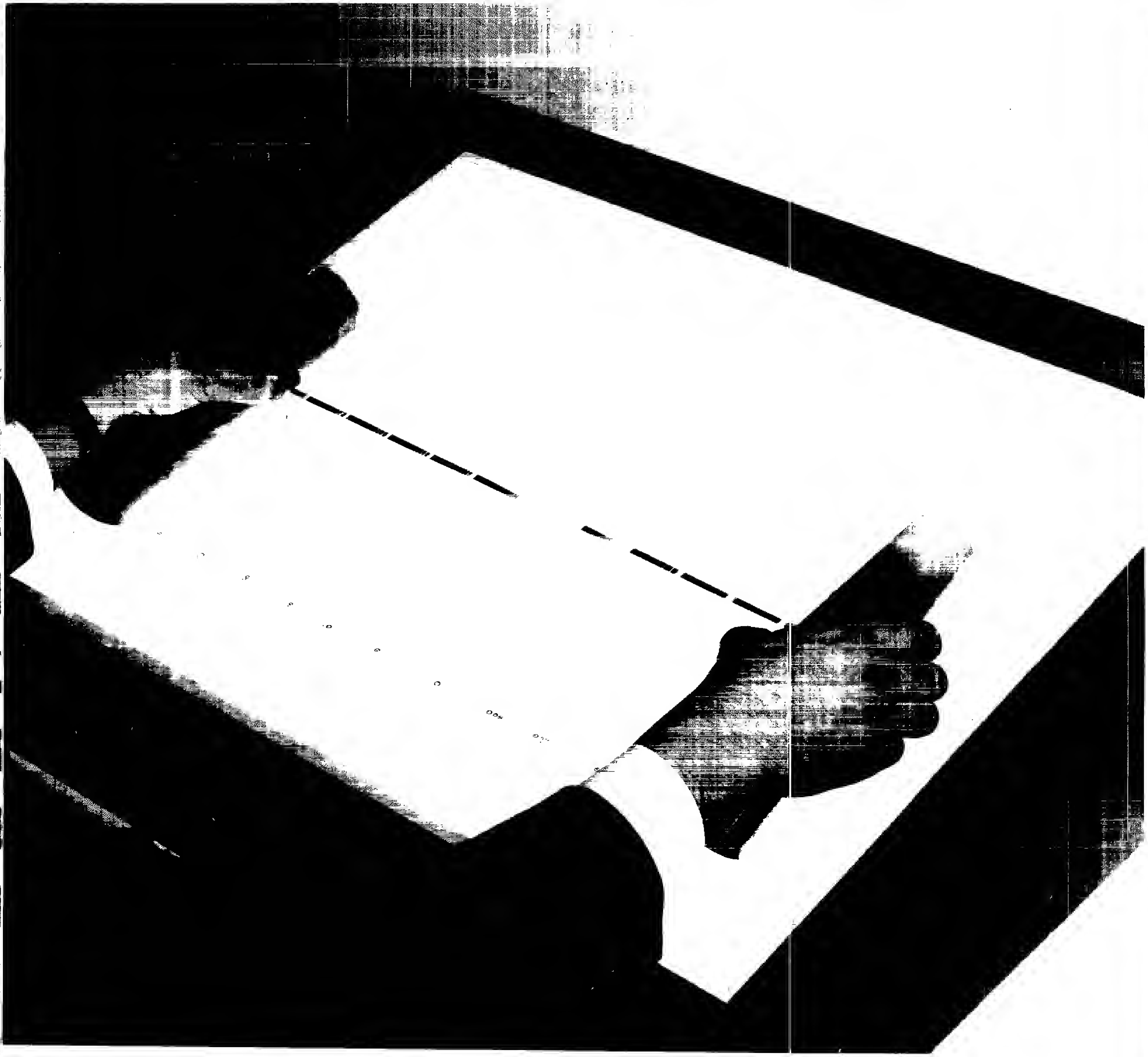
Single patterns

Figure 7



Overlapped pattern pairs
(Note the moire banding)

Figure 8.



A roll test film (T1115)

Figure 9.

Section IV

TEST PERFORMED

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TEST PERFORMED

A. RESOLUTION IN RANGE

In the range dimension the processor is similar to an ordinary 2X enlarger except for some details which should only have a secondary effect on the resolution. For this reason an "ordinary" resolution target of lines and spaces is adequate. This is placed in the platen with the lines running in the azimuth direction, and the resulting image observed or photographed at the output image plane.

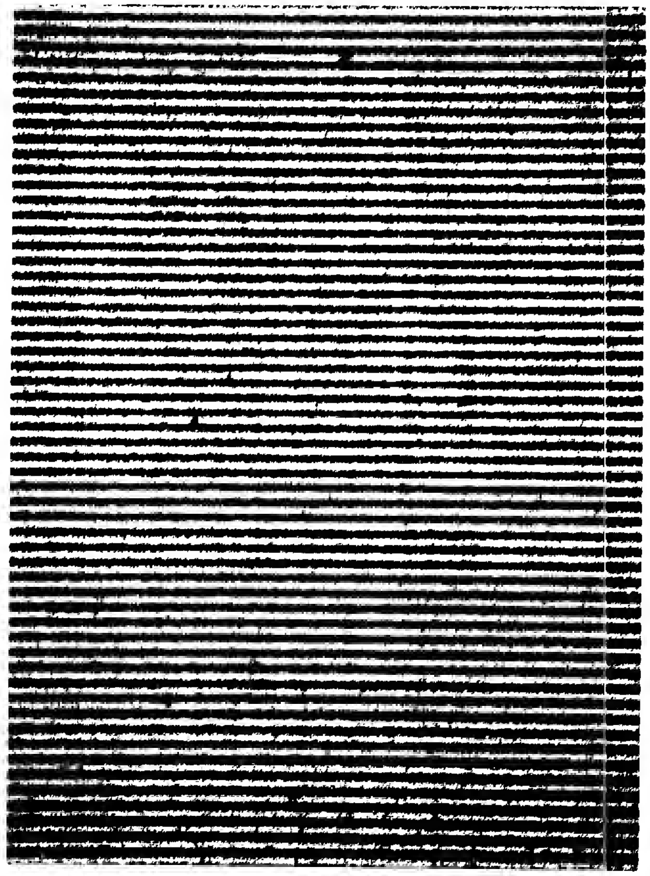
The optical system of the processor must be modified by removing or misaligning the zero order stop since there is no azimuth detail to diffract any light past that stop. This should not have any effect on the applicability of the test data, and some of the tests verify this assumption qualitatively.

The system is illuminated in a very specifically controlled fashion, with highly collimated light in azimuth. This leads to a large amount of diffraction effects which tend to make the viewed patterns complex and raises the question of interpreting the images. An attempt to eliminate this problem by illuminating the platen with incoherent light gave very low resolution readings (only a few lines per mm). Much of this loss was traced to the incoherent illumination. This 4 element lens was designed with ray trace data from rays that will actually exist in the unit. As a result the aberrations are not controlled for all possible

rays passing through any part of the aperture. Tests on a lens bench, without the cylinder lenses, indicated that a diffusely illuminated target gave very low resolution, but that good resolution was attained when the optical path was baffled to limit the rays to those anticipated in the processor. A resolution of 130 l/mm on axis and 90 l/mm at the edge of the field was obtained using a standard 3 line Air Force Resolution Test Chart. The addition of flat glass to simulate the platen and cylinder lens glass thickness made no noticeable changes in the image.

The range tests were re-run in the processor with the aid of this new knowledge. Visual results of 120 l/mm on axis and 80 l/mm off axis were noted, but the data is questionable since the effects of diffraction and spurious out of focus images could not be evaluated. Photographic tests were experimentally difficult, and did not achieve resolution of better than 40 l/mm.

In February of 1963, the long line range resolution tests were re-run with the better cylinder lenses. At this time, it was realized that the limited aperture, especially when the zero order slit was in place, prevented the diffraction from high frequency targets from getting to the image. For that reason, the testing was done on the basis of maximizing and measuring the contrast in a 40 l/mm target. The results from some preliminary tests are shown in Fig. 10. The tests were not re-run at that time, since the range testing is not solving critical problems and thus has low priority.



Range Resolution image (40x)

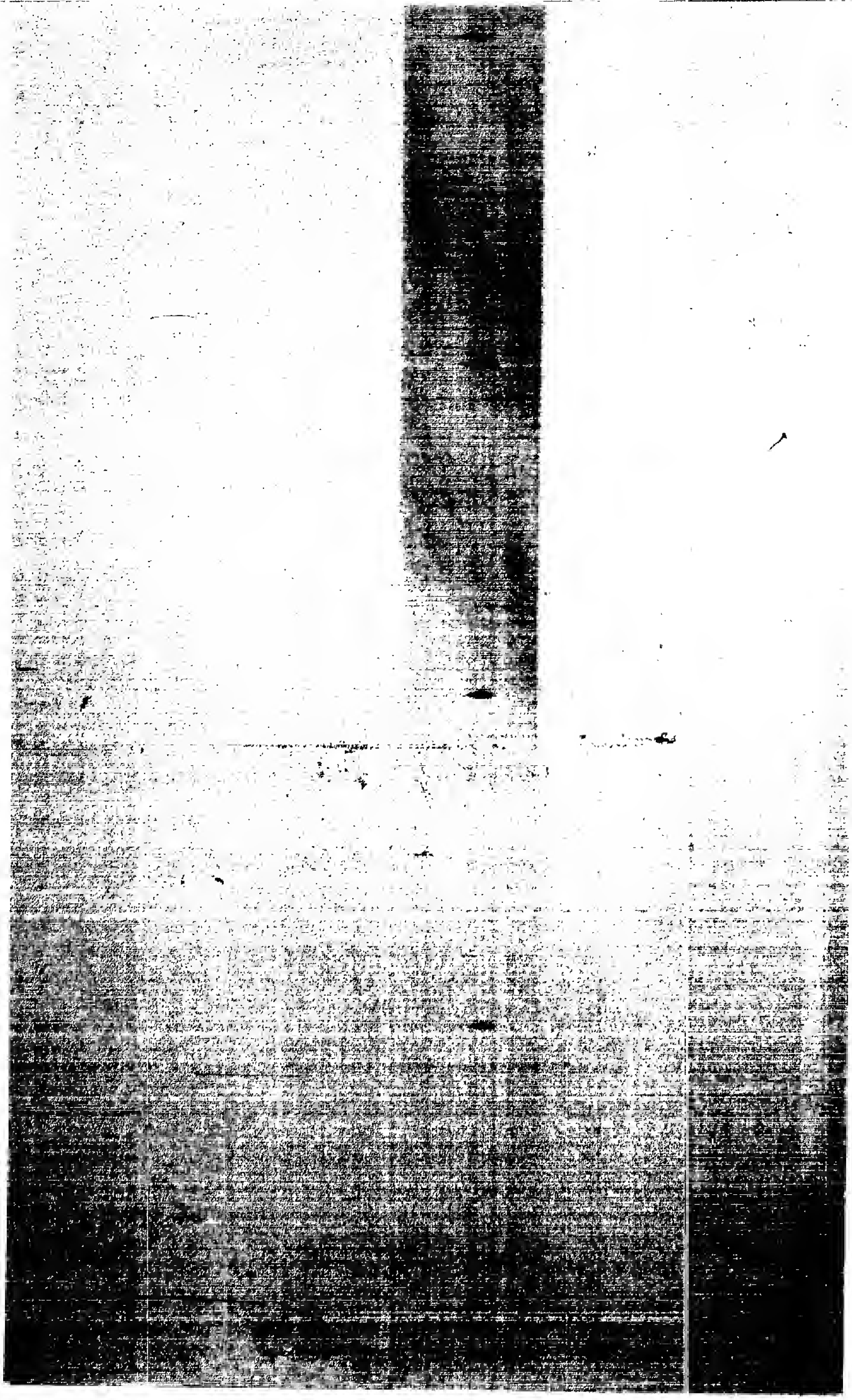
Figure 10.

A second method used to check range resolution was to observe the image formed by a line .002 inch wide scribed along each edge of the patterns (see Fig. 7). When this image is correlated this line leaves a gap in the resulting image. (For example, see Fig. 12 in Section IV(B)). This cannot be assessed quantitatively, but it has maintained a check on the range performance and has the advantage that it is obtained while the system is working in its correct alignment.

Another check on range resolution is obtained by processing a pattern which is approximately .001 inch wide and should give an image about .002 inch wide in range. Attempts to obtain good point images with the old cylinder lenses led to poor results in azimuth, but range image width of about .003 inch were obtained as shown in Fig. 11.

B. IMAGE SIZE IN AZIMUTH

The concept of resolution is based upon obtaining data pertaining to image spread by observing the minimum spearation of lines which can be seen. In the coherent radar system, there are likely to be a number of problems which will tend to affect line width and resolvable separation differently. For this reason, these two quantities are investigated separately in the processor. The line width is covered in this section while the separation is discussed in Section C below.



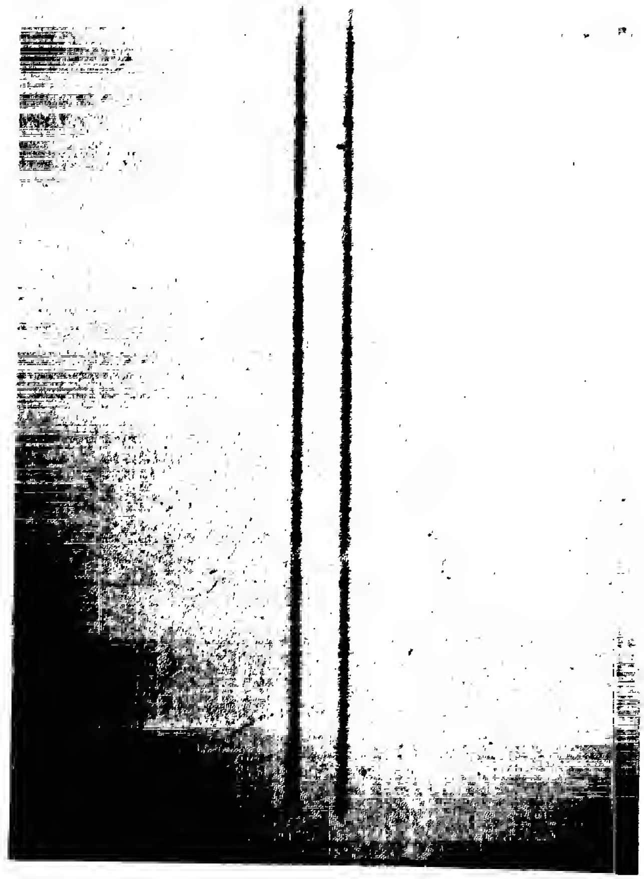
Dot images

Figure 11.

The width measurements have been made on line images formed by patterns as shown in Fig. 7. The first correlated images obtained in November 1961 were observed visually and judged to be diffraction limited (the pattern was relatively short). The images were not photographed, so the data could not be analized and carefully interpreted. Data obtained in May gave line widths of .005 inch to .006 inch in many runs, both static and dynamic. Further tests and observations made during the flight test support work continued to give about the same performance.

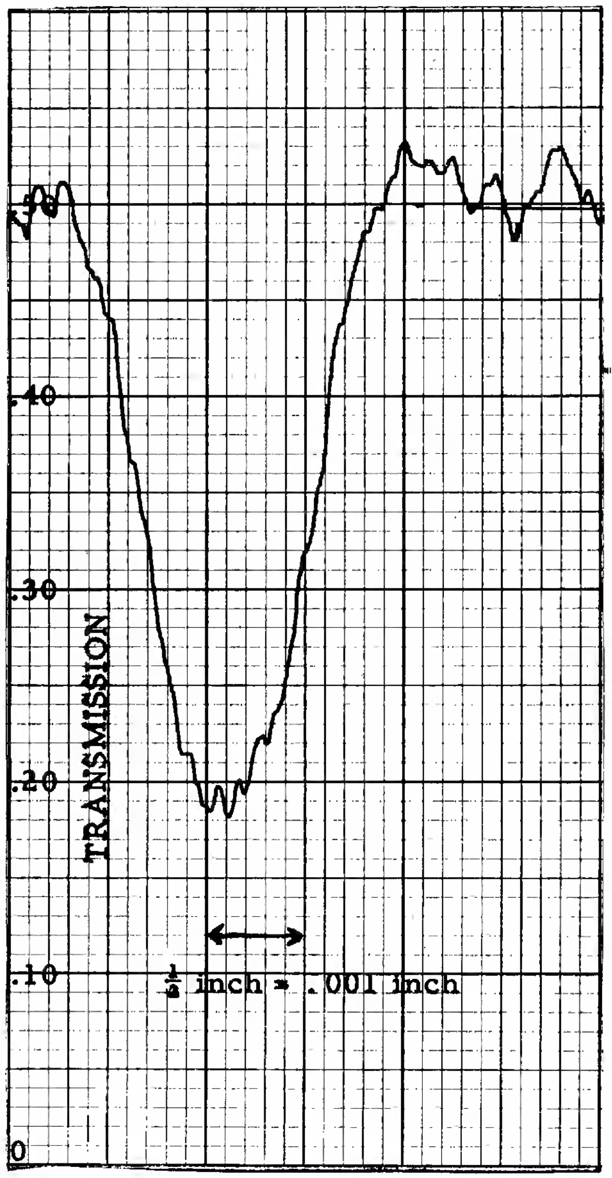
In November, the new cylinder lenses were installed and the line width tests were resumed. Some preliminary line widths of .003 inch width were obtained under idealized conditions (the aperture of the pattern was reduced to give optimum results).

The most reliable data is that obtained in February 1963. This gave a line width of .002 inch with a medium width (15μ) slit and a 0.4% bandwidth interference filter. An enlargement of the image obtained is shown in Fig. 12, and a microphotometer trace of the image is shown in Fig. 13. Attempts to narrow the line below a .002 inch width lead to a critical examination of the test target. The target was found to have some phase error, and new targets are being made (refer to Section III(C)).



Azimuth line width image

Figure 12.



Microphotometer trace of Figure 12.

Figure 13.

C. AZIMUTH SIGNAL SEPARATION

The separation of images of two simulated targets which are close together in azimuth was first tested in February 1962. Most of the patterns used are double exposures of a single square wave test target as described in Section IV(D) and shown in Fig. 8. Images separated by .0045 inch on the output film were resolved with the 24 inch focal length system as shown in Fig. 14. This shows a separation of a weak target near a strong target.

The best image separation data available was made in November 1962. A separation of .0027 inch was photographed, and resolved visually, but the microphotometer traces only resolve .004 inch, which is shown in Figs. 15 and 16. The recent tests giving improvements in the performance were not extended beyond line width tests pending new targets and further decrease of the line width. On the basis of theory and earlier experiments, it is expected that the line separation from simulated pair targets of equal intensity will continue to be approximately the same as the value of the line width.

Some tests were run with 5 overlapped patterns. The sensitometry of the pattern making process becomes much more complex. Film inertia, reciprocity law failure, pre-exposure, and post-exposure effects combine to cast considerable doubt as to the exact nature of the resulting pattern array. The pattern does create five images, although not at as close a

Image separation, weak and strong target (10X)

Figure 14.

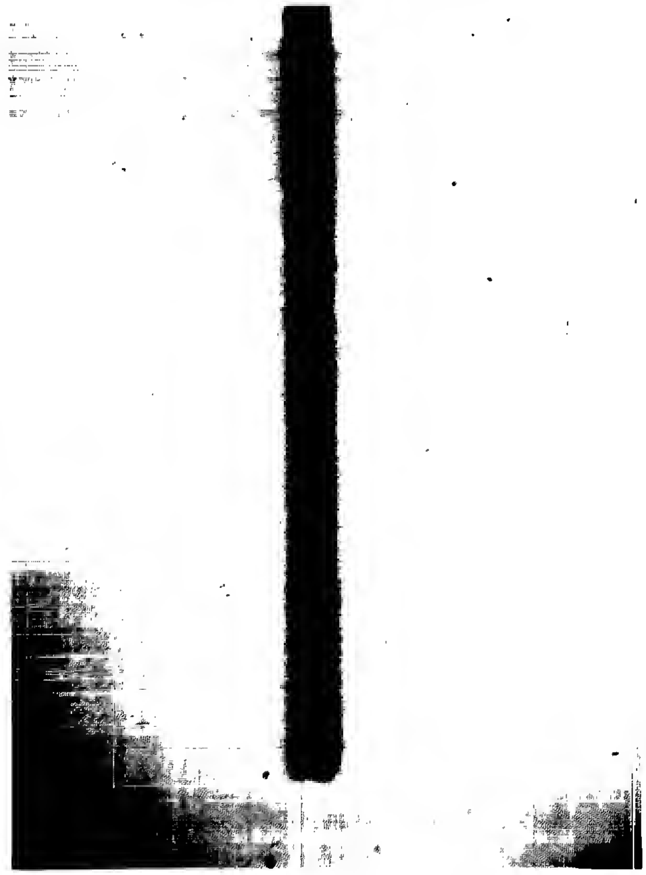


Image separation of .0027 inch (40X)

Figure 15.

Microdensitometer trace of Figure 15.

Figure 16.

separation nor with equal image intensities. A series of images are shown in Fig. 17.

D. FOCAL LENGTH COMPENSATION

This test was intended to demonstrate that the wedge interference filter technique would compensate for the variation of pattern focal length with range. A series of three targets were made for the 24 inch focal length system and checked visually. This test showed qualitatively that the focal length variation was corrected, but the results were not quantitatively conclusive and photographic records were not obtained.

In February, some slightly different tests were recorded which demonstrated that the image does go through focus when the wavelength is changed. The results are shown in Fig. 18. At that time the quantitative interpretation of the data was poor due to the cylinder lens problem, and the experiment was not pressed further.

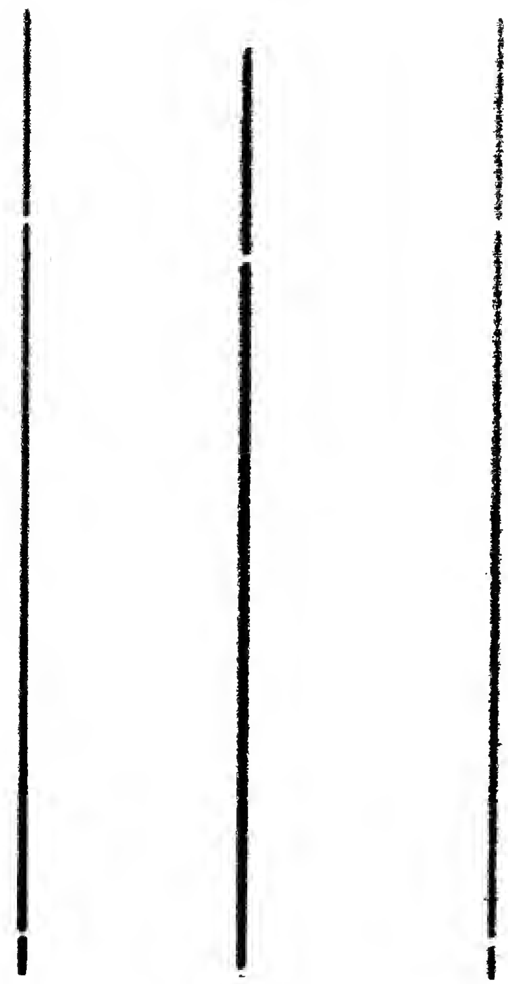
The priority of this test has been low because work performed since the proposal was written has given confidence in the basic technique and has contributed materially toward an understanding of the process.

E. PATTERN TILT

This test was intended to verify the theoretical finding that the azimuth line width and range resolution would be sensitive to tilt angle misalignments of one minute of arc. It was expected that this

Multiple image separation (10X)

Figure 17.



$\Delta\lambda = 0$ $\Delta\lambda \simeq 25 m\mu$ $\Delta\lambda \simeq 50 m\mu$

Effects of Wavelength Variation on Reconstructed Image

Figure 18.

sensitivity would not be experienced until the processor was performing to its full optical capability.

Experience on the processor verified these expectations. It was found that angular rotations could usually be readjusted to within 3 to 5 minutes of arc by observing the two range resolution marks on the line images. A visual test run in April 1962 to determine the effect on line width gave a noticeable spreading with a 5 minute misalignment. The tests using dot patterns described in Section V(A) required that the alignment be within 10 or 15 minutes of arc before the image could be even found in the image plane. Recent experience has indicated that the better resolution obtained with the good cylinder lenses does demonstrate increased sensitivity, a test showed image degradation with a 3 minute of arc misalignment.

F. EFFECTS OF PATTERN FOCAL LENGTH VARIATIONS

This test was intended to check the depth of focus of the instrument and determine the image deterioration with focus errors. The primary purpose of the test was to obtain data to assist in developing focus control techniques.

The depth of focus has usually been found to be very large. In January 1962, the depth of focus for the 24 inch focal length system was found to be $\pm .030$ inch. The 150 inch system with poor cylinder lenses usually was insensitive to focal shifts of $\pm .050$ inch or more. Recent tests have shown a depth of focus of $\pm .015$ inch for range and

±.025 inch for azimuth. Both of these figures are considered to be too large, however. The range test was run at a coarse (40 l/mm at the input) resolution and thus requires microsensitometer data for evaluation (the data and equipment do not justify this refinement as yet). The azimuth depth of focus was partly due to phase errors in the patterns which tended to give a sequence of focal points.

G. SIGNAL INTEGRATION

This test was intended to study some of the noise effects and signal to noise improvements to be expected in the processor. These tests were intended to be run after most of the other tests were completed. Some preliminary tests were made in May with a grainy input target. The noise has very little effect on the pattern obtained.

This problem actually relates to the interaction within the entire coherent radar system, and it will be considered in the testing to be performed in 1963.

H. MOVING FILM TESTS

The film drive must meet very rigid requirements in the processor. It was found to be very difficult to test the film drive in any test other than to run film in the processor. The final proof of adequacy of the drive was to be accomplished by comparing static and dynamic runs of the same target. Even this test is actually fairly difficult since the tilt angle of the target changes when the film comes to rest for a static test. General experience has indicated that the

results of static tests can be repeated dynamically after the tilt and drive ratio adjustments are optimized. A series of tests run in May show no difference in static and dynamic tests, and a later check in November showed no measurable image smearing on .003 inch wide lines.

Section V

SUMMARY

Section V

SUMMARY

The Work on the Test and Simulation Program has moved continuously toward the desired goals. At the present time, useful data is available on most of the specific tests, but the data is not final since neither the processor nor the simulated patterns have been fully optimized.

The best data obtained to date is given in Table IV. Tolerances have not been given since the dependability of the data rests more on the interpretation of the data rather than the usual statistical or measurement errors.

The development and performance measurement will be continued under the Performance Studies Program, 9015.22.

Table IV

SUMMARY OF TEST AND SIMULATION DATA

Item	Month	Test Target	Sensor	Results	Comments
A. Range Resolution (referred to input platen)	Feb. 1962 Feb. 1962 Feb. 1963	T1 T1 T21	visual visual pan X-monobath	130 l/mm 90 l/mm above 40 l/mm	on axis off axis entire field
B. Azimuth line width (at output platen)	Feb. 1963	T215	pan X-monobath	.002 inch	imperfect pattern. 15μ slit width. 0.4% bandwidth filter.
C. Azimuth signal separation	Nov. 1962	T215	plus X, DK-50	.004 inch	
D. Focal length compensation	Feb. 1962	T5	plus X, monobath	---	The technique has been qualitatively verified.
E. Pattern tilt	Feb. 1963	T215	visual	3 min. of arc	sensitivity to misalignment
F. Focal length variations	Feb. 1963	T215	pan X, monobath	$\pm$.025 inch	depth of focus in azimuth
G. Signal integration					no useful data
H. Film drive	Nov. 1962	T215	plus X, DK-50	less than .0005 inch image smear	dynamic resolution as good as static resolution.

Appendix A

DOCUMENT LIST

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DOCUMENT LIST

Document	Date	Document No.
Proposal #3320	August 1961	SHC-209-61
Addendum to #3320	October 1961	SHC61-271
Progress Report	November 1961	SHC61-9015-158G
Progress Report	December 1961	SHC62-9015-08
Progress Report	January 1962	SHC62-9015-57
Progress Report	February 1962	SHC62-9015-77
Progress Report	March 1962	SHC62-9015-176
Progress Report	April 1962	SHC62-9015-172
Progress Report	May 1962	SHC62-9015-195
Progress Report	June 1962	SHC62-9015-237
Progress Report	July 1962	SHC62-9015-238
Progress Report	August/Sept 1962	SHC62-9015-331
Progress Report	October 1962	SHC62-9015-359
Progress Report	November 1962	SHC62-9015-384
Progress Report	December 1962	SHC63-9015-42
Progress Report	January 1963	SHC63-9015-77
Progress Report	February 1963	SHC63-9015-103
Added Scope Proposal	July 1962	SHC62-9015-215